NSLS-II Project Advisory Committee Report
October 26-27, 2006

The inaugural meeting of the NSLS-II Project Advisory Committee was held on Oct. 26-27, 2006 at Brookhaven National Laboratory. Committee members in attendance were: T.E. Mason (Chair), G. Shenoy, R. Hemley, G. Materlik, and W. Hendrickson. W. Stirling and A. Wrulich were unable to attend.

The committee was given a general overview of the NSLS-II conceptual design and project status and more detailed presentations on Project Management, Accelerator Systems, Experimental Facilities, and Conventional Facilities. In addition reports of the three technical advisory committees (Accelerator –ASAC, Experimental – EFAC, and Conventional – CFAC) were reviewed and briefings in telephone conferences were held with the respective committee chairs.

The committee would like to thank the NSLS-II staff for their efforts to educate us about the plans and objectives of NSLS-II and look forward to interacting with the project at it progresses to completion. This report is organized following the outline of the presentations to the committee with an overview/summary of conclusions and then subsection on project management, accelerator, conventional, and experimental facilities.

Summary:

The PAC was impressed with the efforts towards developing a conceptual baseline with a preliminary cost and schedule range in preparation for the upcoming Conceptual Design Review. We believe that an appropriate risk adjusted cost model has been developed and the primary uncertainty in the overall budget for NSLS-II is driven by questions of scope that are discussed in the relevant sections below.

Two areas that we feel warrant particular attention are the need for an integrated staffing plan; to validate the scope of office and laboratory space, pre-operations costs, and personnel transitions between NSLS, CAD, SMD, and NSLS-II; and the need for a clearly defined relationship and transition between NSLS and NSLS-II. The latter is of particular significance since it impacts the user community whose support and engagement is crucial to the success of NSLS. The transition plan between the two facilities needs to be developed and communicated clearly since there is an intrinsic conflict between the desire for a seamless transition of scientific programs (maximization of overlap) and the practicalities from a budget, personnel, and instrument development point of view which drive toward minimizing the overlap. Communicating to the user community that there will be one year of facility operations overlap leads easily to the incorrect assumption that the experimental capabilities will not have a gap. It also implies a several year overlap of NSLS operations and NSLS-II pre-operations which will be very difficult to manage institutionally.

The committee requests that future meetings be structured to permit more time for committee deliberations and drafting of an initial report. We would propose holding the meeting over two days, with the first day devoted to formal presentations and the morning of the second devoted to committee deliberations and unstructured discussion with NSLS-II staff as needed. The meeting could wrap-up with lunch and a closeout session to permit member travel that afternoon/evening.

Project Management/Organization:

An experienced Project Management team is in place and developing the tools that will support project planning and execution. The PAC was very impressed by the WBS cost and schedule data collection process at this stage of the conceptual design. The cost estimate is based on a 35% contingency and escalation factors that are based on experience. This initial contingency allocation is prudent at this stage although there seems to be a tendency to view it as large enough to support additional scope beyond the baseline. This may eventually prove to be the case but care should be taken to insure all essential scope is included in the baseline since contingency cannot be counted on and timing of its availability may preclude some uses (changes in conventional facilities scope are likely to need decisions too early in the project to allow major contingency allocations for additional scope).

The cost estimate reflects the Brookhaven special project overhead rate and the identified staff resources needed for design and construction. Pre-operations planning appears somewhat notional at this stage and is strongly dependent on the eventual operating costs of the completed facility which has not yet been developed from the bottom up. The PAC is concerned about the size and the scope of the R&D plan in all the areas of the project. Since this affects the TPC, we would suggest that all open ended R&D be avoided. The R&D should only be "R&D in Support of Construction." Strict adherence to this definition will define the scope of the R&D projects and establish a schedule consistent with the schedule for construction project deliverables. The R&D must have a WBS structure with milestones and schedules, and a cross-correlation matrix between the WBS elements of R&D and Construction project must be developed. The Committee notes that there is precedence within the DOE system for the special project overhead rate to apply to R&D in support of construction for the same reasons that cost is captured as part of the Total Project Costs (SNS for example). This would represent a significant cost avoidance for NSLS-II.

One of the major cost driver for any major project is staff. The estimate is based on composite rates by effort type and effort for the defined tasks. There does not appear to be a detailed staffing plan that flows from the cost estimate and can be used to plan hiring, transfers to and from other divisions, and demonstrate a logical ramp up to the full operating level. Such a plan would also serve to validate the planned lab and office space both within NSLS-II scope and available onsite. We recommend development of a staffing plan linking the project resources to the eventual full operating staff. This will provide a basis from planning some of the complex staff transitions that will need to occur between NSLS-II and CAD, SMD, and NSLS. The NSLS transition is particularly tricky because it is assumed that NSLS operations will overlap NSLS-II for one year to help provide continuity for the user program. Since NSLS-II pre-operations will begin a couple of years prior to this there is a significant period during which there will be two staffed, operating facilities followed by closure of NSLS. There seems to be an implicit assumption that NSLS staff will transition to NSLS-II operations. This will be difficult to achieve since staff, even operations staff, will be needed well in advance of NSLS-II completion for design, construction, pre-operations and R&D. Without careful planning and communication there is the potential for conflicting demands on NSLS operations and NSLS-II jeopardizing both.

With regard to organization structure, the 'insertion devices' group is always an odd entity. There are advantages of having this group as a part of either Experimental Facilities or Accelerator Systems. The advantage of having it in Experimental Facilities is that the device design gets a direct input reflecting the user needs, and if it is under Accelerator Systems, the IDs become a black box delivering the radiation to users. There are similarities between IDs and neutron target and moderators at a spallation source. While PAC does not want to belabor this issue, it would suggest a serious revisit to this topic after the permanent heads of both these units are appointed.

A very high priority with regard to current organization is to designate individuals responsible for the interfaces between the three units, namely the conventional facilities, accelerator and the experimental facilities. Individuals with proven experience with such coordination must be immediately appointed before the design matures any further. If this action is not taken at the present design status, there will be both cost and schedule implications in the future. A very well defined process and schedule must be established to hold intra-group, inter-group, and inter-divisional meetings and to communicate the results to all involved. Implications of such meetings to each of the WBS elements must be managed proactively to understand the impact on both cost and schedule.

Accelerator Systems:

The NSLS-II Accelerator Systems Advisory Committee (ASAC) is made up of well regarded accelerator experts with considerable experience in designing, constructing and operating third generation synchrotron radiation facilities around the world. The ASAC reports such as the one provided by ASAC from their meeting on October 10-11, 2006 will be very useful in realizing the technical goals of NSLS-II accelerator system. The accelerator system as presented, consisting of a DBA lattice with additional damping wigglers, will achieve the design goal of 1 nm-rad for the transverse emittance of the 3 GeV electron beam. Based on the presentations at the PAC meeting and the draft ASAC report the PAC did not see any show stoppers in achieving the goals in the design concept presented to the committee. The PAC was encouraged to hear that the search for a permanent Director of the Accelerator Systems Division is nearing completion.

The PAC has the following additional observations from the presentations at its meeting held on October 26-27, 2006:

1. The need to reduce the horizontal beam size by lowering the value of the beta function is essential for many coherent imaging/diffraction beamlines. This flexibility should be built in the lattice from the beginning.

2. No design of the beamline front end was presented at the review. It is important to establish whether a double redundancy (duplicate beam stops, duplicate safety shutters, duplicate PSS, etc) in the design is required by current accelerator safety and local

DOE/BNL safety requirements. The double redundancy was required when APS was constructed. This adds much cost to the front ends.

3. Reduction of the unwanted radiation produced by dipoles, quadrupoles, sextupoles and correction magnets along the straight section line-of-site is detrimental in the successful operation of x-ray BPMs on undulator beamlines. There have been different schemes implemented at various facilities. For example, a small distortion in the storage ring lattice is introduced at the APS to reduce such radiation along the line-of-sight or canting the ID’s is used at other places. This should be planned from the beginning.

4. Top-up operation should be fully planned and included in the project scope. The project SAD should include all the requirements to perform top-up. The Experimental Facilities SAD should be written in a way that the SAD includes a beamline readiness review process that is approved by the DOE. DOE may witness the implementation of the process at only one of the early beamlines. This will give the Facility the authority to approve the commissioning on future beamlines without a separate approval from DOE.

5. There have been phenomenal improvements in undulator technology and the quality of available magnet materials suitable for x-ray FELs. The committee urges the ID group stay abreast of these developments and more specifically make contacts with personnel at FEL facilities such as DESY.

6. Many of the accelerator subsystems are proposed to be procured from qualified vendors with demonstrated track record. The PAC supports this approach, however concerned that the most established vendors are limited in number to a few establishments in Europe, Russia and China. Some of these vendors are already overburdened and have delayed their promised deliveries to many synchrotron facilities in UK, Germany, France, Spain and Australia. The procurement process must receive great attention and managed with care throughout the entire project duration. The PAC would like to hear the planned approach at the next review with a complete risk analysis including an assessment of foreign currency risk exposure.

7. It is PAC's opinion that basic diagnostics for qualifying undulators and optics metrology capability should be part of the project. Performing measurements on cryo-cooled PM undulators will be a new need for NSLS-II. These needs will have to be conceptualized, designed and built in advance and a determination made as to what elements of the effort fall into project R&D, construction, and perhaps LDRD.

8. The synchrotron infrared (IR) program at the NSLS, with its half dozen beamlines, is one of the features of the facility that makes it unique in the world, particularly in the far-IR and THz region. This area of synchrotron radiation research continues to grow. It is therefore quite encouraging to see the plans for IR beamlines, including 5 with 60 mm gaps for large solid angle collection of long wavelength radiation to maximize flux in the far IR We heard about the prospects for edge radiation approaches. Neither approach is proven technology. The edge radiation has not had the impact of dipole facilities at the NSLS; moreover, it isn’t clear that the large gap BMs will work with the ring (i.e., not

compromise the storage ring parameters). This problem needs to be explored in much more detail, and contingency plans considered for maintaining a strong IR component at NSLS-II (including restoring the earlier plan for moving the existing IR ring to the facility).

Conventional Facilities:

We are pleased to see NSLS-II soliciting input on their Conventional Facilities through CFAC – there is a tendency to focus attention on challenging technical systems and regard conventional facilities as straight forward. Experience has shown that for an accelerator complex of the scale of NSLS-II the Conventional Facilities are far from conventional. We would particularly highlight the CFAC comment that the NSLS-II CF go beyond business as usual for BNL and will require careful shepherding of the flow of technical requirements into CF scope in order to control costs. It is likely that given recent construction experience around the country there will be a lot of concern about the cost estimate until the awards are made. There is an effort to recognize this risk through the escalation and contingency analysis applied to the cost estimate. It will also be very important to have a tight loop between cost estimating and design to avoid creep that leads to a “surprise” at award time. The team should also try from the start of construction to establish a very tight change control and change management to minimize any cost escalation. In addition a strong quality control on the installation of all mayor technical components should be put in place to avoid surprises from poor workmanship during the construction process.

Perhaps a greater concern for the CDR phase of the project is the definition of the scope of Conventional Facilities, in particular the laboratory and office space. Taken in isolation it is clearly inadequate when compared to other similar facilities or the anticipated scale of NSLS-II operating staff and users. However, the space built as part of the construction project is likely to be supplemented by other BNL space including NSLS, the planned JPSI facility (both of which are in close proximity to NSLS-II) as well as shop space to support accelerator operations (magnet measurement facilities for example). It is possible that with this additional space there will be adequate support space for NSLS-II; however, we would note the likelihood that other organizations (including SUNY Stony Brook and other BNL departments in the case of JPSI) will also have aspirations regarding that space. As a result it is not possible to be sure that the NSLS-II baseline will meet all of the likely needs.

In order to validate the baseline scope it will be necessary to develop the staffing plan for NSLS-II operations and the required lab and shop space. There will have to be a tabulation of non-project space that will be devoted to NSLS-II operations and user program (as distinct from supporting research programs) with a laboratory commitment to that space allocation. This space allocation together with the NSLS-II construction scope should then be matched up against the operating plan and benchmarked against existing synchrotron facilities (APS, SLS, ESRF etc) with suitable adjustment for number of sectors etc. It will probably not be possible to develop this to the full level of detail by the time of the upcoming Conceptual Design Review but at least a preliminary analysis is warranted to insure that an assumption that all requirements must fit within the NSLS-II baseline leads to a conclusion of inadequacy. General assertions about additional space will not be sufficient to address this concern.

A particular concern of the PAC is that the planned support laboratory space near the beamlines in the LOBs is insufficient. Though it is expected that some users will be satisfied to simply bring samples for experiments, a growing number of complex experiments carried out at synchrotron facilities require off-line characterization and experimentation. Sufficient laboratory space is needed to make these experiments successful; experience at many facilities demonstrates that both users and beamline personnel need facilities in close proximity to the beamlines (which makes redeployment of existing space problematic). The APS has approximately twice the laboratory/office space adjacent to the experimental floor, and this is insufficient for many programs. We suggest that the space allocated to the LOBs in the current planning is a factor of two too low. Not all of this space is required at start up but the total footprint, including planned additions, needs to be capable of reaching full operational status over time.

There is a major emphasis on the vibration stability of the storage ring girders in the present design. The PAC endorses this need in the design, but emphasizes that similar considerations be given to all other subsystems such as the undulator support, beamline components, x-ray BPMs, and optics. It is equally important that vibration sources from the mechanical systems such as pumps, fans, fluid flows, cooling towers and HVAC systems be isolated from the accelerator and beamline subsystems. The proximity of the service buildings to the storage ring tunnel may exacerbate this problem. The present design of increasing the thickness of the slab under the storage ring girders is expensive. A careful vibration design study must be conducted to minimize the thickness and radial width of the slab since this will be a major cost saving for the project. The limited space available for the installation and maintenance of the beamline front ends located inside the tunnel is a major concern to PAC. The committee was told that this situation will be mitigated by the introduction of movable ratchet doors from the experiment hall, although none of the layouts presented to the committee showed such designs. While they are essential, the ratchet doors will add to the cost of the project.

The committee notes that the plan for the CLOB provisionally includes an auditorium similar in size to the existing Berkner Hall, which has served for NSLS user meeting for many years and is reasonably close to NSLS-II. Berkner Hall could certainly benefit from updated seating and audio-visual but any plan for a NSLS-II auditorium should be discussed in terms of the overall plans for upgrading and/or new facilities at Brookhaven as a whole. Given the squeeze on funding for beamlines and laboratory floor space, the exact needs for auditoriums and conference rooms of various sizes should be examined very critically.

Experimental Facilities

NSLS-II has the dual mission of delivering world-leading performance for nanoscale science, specifically including ~1nm spatial resolution and ~0.1meV energy resolution, while at the same time accommodating the large and diverse existing NSLS user community with state-of-the-art instrumentation. It is at once a major green-field project and a facility upgrade, and its ultimate success depends on executing well for both missions. This is an unprecedented mandate for DOE user-facility projects – NSLS itself, ALS, APS and SNS each established completely new capabilities at their respective sites. The SPEAR-III upgrade at SSRL/SLAC did have to address shutdown issues, but this did not feature new capabilities at the scale expected from NSLS-II.

Both the cutting-edge and the state-of-the-art capacity aspects of the NSLS-II project present substantial challenges for experimental facilities.

NSLS-II will include both facility-run beamlines, including all those supported by BES, and user-run beamlines supported by other organizations. The NSLS-II project will fund an initial suite of beamlines (from 5 of 27 user straights in an initial plan), and subsequent BES support is expected through the MIE mechanism. NSLS-II has developed a Trust Fund approach to assure the budget for the initial set of beamlines. The Trust Fund will also support front ends and insertion devices for these beamlines. The number and character of those beamlines will be specified at a later date; input on these decisions needs to be provided in a timely manner. Initial instrument concepts have been developed for the purposes of cost estimating but will be replaced by actual instruments through the EFAC peer review process.

Beamlines will be created through the BAT program for facility-run beamlines, whether project funded or MIE funded, and through the BDT programs for user-run beamlines. The plan for 25% beamline access in years 1-4 for the BATs, with substantial access to contributing users (CUs) in subsequent years, is both reasonable and necessary for insuring that good groups invest now in beamline planning and development. There is a need to speed up the process in order to get early involvement of the user community. This is true both for the initial project-supported beamlines and also for developing a compelling case for MIE funding. It is essential to take advantage of the large, existing NSLS user community. The program needs to be science and user-driven. “If we will build it, they will come” is not the correct model. Procedures for the evaluation of BATs and BDTs, while necessarily somewhat different, should be coordinated to set comparable standards for both.

The BDT program will rely on support from programs outside of DOE-BES (e.g., from NSF, NIH, DOE-NNSA). Communities seeking such funding need to be able to plan for this immediately. A pre-proposal is not sufficient to secure construction funding, but facility endorsement from such a process will be essential. Programs need to be nurtured, if not created, within these agencies to support beamlines as well as perhaps broader (e.g., facility-wide) programs. Proposals to NSLS-II should be evaluated iteratively, and the NSLS-II should adopt procedures that enhance success with funding by outside agencies. New opportunities being discussed within DOE for joint funding of projects (e.g., beamlines) between Science and NNSA should be explored (for BATs and BDTs).

The life sciences, notably macromolecular crystallography, is the basis for a large fraction of the user community at NSLS as at other synchrotron facilities, and this should be a large component of the BDT program. It is not at this time clear how support for these BDT beamlines will materialize, but this must be addressed urgently to assure that appropriate beamlines be available to meet the transition from NSLS to NSLS-II. The NSLS community cannot afford the protracted development schedule of biological beamlines at the APS, for example. NSLS-II has from the beginning been a project based on the great success of the NSLS user community, so it comes as a surprise to PAC that not even one MX beamline is among the initial set of beamlines. Other non-BES programs, such as environmental sciences, face a similar dilemma.

The dual goals of achieving 1 nm spatial resolution and 0.1 meV energy resolution is compelling and exciting as it will push the state-of-the art and defines the performance requirements for the NSLS-II accelerator. An aggressive R&D program is needed to accomplish these. The utility of NSLS-II is not limited to those specifications however and it is important that the pursuit of these machine goals not compromise other scientific needs of importance to other eventual users (e.g., IR capabilities, time resolved experiments, etc.).

Prior to submission of the original NSLS-II proposal, a series of workshops was held and input from a broad range of users provided. It is not clear how this vision is being captured and continued in the dialog between NSLS-II staff and DOE during the current rapid pace of reviews. The peer review process carried out through EFAC is critical to developing the engagement and commitment of the scientific community. For that reason composition of the committee is key and we have some suggestions, which will be transmitted along with (but separate from) this report. The membership of EFAC should reflect the various constituencies within the user community scientifically as well as their affiliations (university, industry, national lab). There should also be a healthy mix of users and instrumentation experts.

The criteria for selection of beamlines (both project funded and others) should be:

- first and foremost the excellence of the scientific case and engagement of the user community in its articulation
- a best-in-class beamline whose performance characteristics are well matched to NSLS-II source performance (in this context best-in-class means instrument performance that meets or exceeds relevant benchmarks worldwide based on realistic simulations of instrument performance)
- the technical feasibility of the proposed concept in reaching the scientific objectives

These criteria do not include either level-0 baseline objectives (0.1 meV, 1 nm) for NSLS-II or existing NSLS programs explicitly, although both will be elements of the decisions in a natural way since the source characteristics lead to exploitation for better spatial and energy resolution and the engagement with the user community demands involvement of the NSLS user base. This formulation also leaves open the possibility of instrumentation that takes advantage of NSLS-II in ways not included in the level-0 baseline and in ways not represented in the current user base. This flexibility is important since many things will be possible at NSLS-II that cannot be done at NSLS.

Decisions about distribution of beamlines need to have user input; for example the 20 VUV/soft x-ray ports; 10 IR. The current user pool at the NSLS can provide continued input (e.g., with workshops and a proactive EFAC). The user community should also provide input on central facilities support. An example is the sample environment approach proposed early on in NSLS-II planning workshops – that is, to follow a neutron facility approach to experiments in extreme temperatures, pressures, and magnetic fields – as opposed to having dedicated beamlines for these types of experiments. The dedicated beamline approach was followed at NSLS and APS, but it is clear that there is a need for a broader effort with central facilities that can support activities in these areas. Indeed, there is an effort underway to do this at the APS for extreme conditions research. That field is moving away from dedicated beamlines (like those at NSLS and APS) to a distributed approach following the neutron scattering facility sample environment model.

NSLS-II has evolved considerably since the input from the users received three years ago. Also a user steering committee has not been established for NSLS-II in order to engage in a dialog with the users regarding the evolution of the project. The PAC encourages the management to appoint a permanent head for the Experimental Facilities unit who can proactively include users at all planning activities and serve as an advocate for the science mission within the management team. In order to avoid a sibling rivalry developing between NSLS and NSLS-II consideration should be given to interacting with a unified user group, perhaps with sub-committees of the executive devoted to each facility. This structure can also lead to a smooth transition planning when NSLS curtails its operation and the users move over to NSLS-II. It is essential that the User Executive Committee and user community more broadly have confidence in the beamline selection process adopted for NSLS-II.

With only five beamlines included in the Trust Fund, it is of prime importance for the NSLS-II management to proactively support the users seeking external funding to build additional beamlines. It is this committee's view that closer to 15-20 beamlines should be constructed (with project funding and other sources) with completion dates close to the start of operations to justify the investment into the major user facility, to support transition of NSLS users, and to remain competitive on the word science scene. While a few components of the existing NSLS beamlines may be used for building NSLS II beamlines, this will be of minor consequence on the scheme of things. The PAC is skeptical of the merit of moving entire beamlines from NSLS given the very different machine characteristics, age of the instrumentation, and rapid evolution of instrument technology. That said, it remains crucial that NSLS-II development be coordinated tightly with current NSLS operations and consequent opportunities. The PAC is concerned that, even in the best of anticipated circumstances, there will be a dim period for functional beamlines during the transition.

The creation of the Joint Photon Science Institute (JPSI) presents an important opportunity to enhance NSLS-II, both well before and after opening of the facility. As described in the presentation materials, it will be a ‘gateway’ to users with a broad range of applications, building the user base for NSLS-II. Development of the synchrotron based science needs to proceed in parallel with the NSLS-II. JPSI should be broadly inclusive of the science that will be performed at NSLS-II. In some of these central facilities support is essential (as well as cost-efficient, avoiding duplication). Again, it is important that the user community be involved now to identify critical needs and areas to develop.

A guest-house facility is another incremental activity outside the NSLS-II project but very important for the success of NSLS. Planning is underway for third-party funding of such a facility to be located proximate to NSLS-II and to CFN. These are, by far, the dominant user-oriented activites at BNL, and both communities are already present and needing of such a facility. Thus, BNL management should strive to expedite development of a viable Guest House plan and also prepare for alternative options.